Development of an Atmospheric Mercury Modeling System for the Great Lakes Region

Progress Report for the Quarterly Period Ending March 31, 2003

Wisconsin Department of Natural Resources
Mercury Analysis Team

The Mercury Analysis Team, part of the Wisconsin Department of Natural Resources' (DNR) Air Management Program, is responsible for developing an atmospheric mercury modeling system for Wisconsin and the Great Lakes region. Partial funding for this effort comes from a grant awarded by USEPA in October 2001. The team identified seven major areas of work and the lead staff for each as follows:

- Atmospheric Chemistry Modeling, Mike Majewski – WDNR
- Meteorological Modeling, Wusheng Ji – WDNR
- Regional Emission Modeling, Gwendolyn Judson – WDNR
- Mercury Inventory Development, Orlando Cabrera-Rivera & Grant Hetherington – WDNR
- Data Analyses, William Adamski, Grace Liu & Sanober Durrani – WDNR
- Mercury Monitoring, Mark Allen – WDNR
- Computer Resources, Mike Majewski – WDNR

Atmospheric Chemistry Modeling

ENVIRON and AER are enhancing the Comprehensive Air quality Model with extensions (CAMx) to include Mercury (Hg) chemistry and deposition for Wisconsin Department of Natural Resources. WDNR has provided feedback to ENVIRON during conference calls on the progress of their work. WDNR expects a beta version of the model in late April 2003. We will then use the latest inventory we have available to test model performance.

Meteorological Modeling

In this Quarter we had completed an annul MM5 run for ENVIRON who need the meteorology fields to develop a mercury model for us. The annul MM5 simulation run starts on Jan. 1, 2002 and ends on Dec. 31, 2002 with a coarse gird that is the same as the LADCO/Midwest Regional Planning Organization (MRPO) 36km grid. The domain had 165X129 grid points and covered the most of the North America. Atmosphere input data include the NCEP GDAS analysis, NCEP Eta model output, NCEP surface and upper air data. The model had 34 vertical layers with the simple ice for the moisture scheme, Kain-Fritcsh for cumulus parameterization, Pleim-Chang for PBL and Pleim-Xu for soil model. The MM5 model simulation run was accomplished in about three months with our Linux computer.

The preliminary model performance evaluation based on the METSTAT analyses indicates that the MM5 produced reasonable meteorology fields for the mercury modeling. METSTAT is a set of software designed to analyze the MM5 model output, capable of comparing and displaying the differences between the MM5 estimates and observation. The fields analyzed by MESTAT are wind speed, wind direction, temperature, and humidity. Initially METSTAT shows that all the annul meteorology fields produced by MM5 for the first ten months of year 2002 are very close to the observations with an acceptable range of bias except temperature which had a higher bias for the first four months of the simulation. Table 1 below shows the daily temperature bias in Celsius between January and October 2002 for the three sub-regions of the Upper Midwest as shown by Fig. 1 which covers the cenrapN, Great Lakes and Ohio Valley. It indicates that the temperature bias for months of January, February, March and April is about 1C to 2C lower than the other months. Table 2 is the daily gross error for the same region; again it indicts that the gross error is

about 1C to 2C bigger for the first four months than the other months. The METSTAT did not reveal any major bias for the wind speed, wind direction, and humidity.

We will continue working on our shorter MM5 episode for year 2001 in the coming quarters, and finishing the model performance evaluation for the annul 2002 run including the METSTAT analyses for last two months if the NCAR observation becomes available.

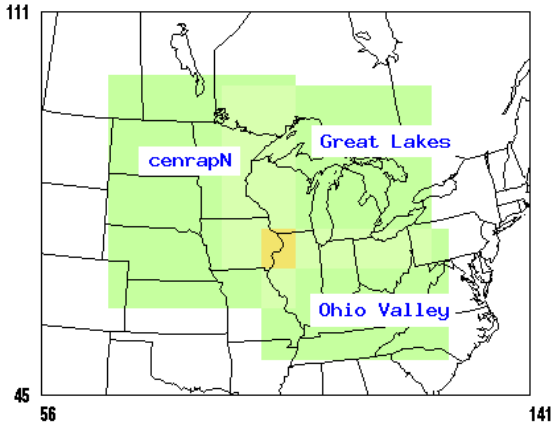

Fig. 1 The three sub-regions of the Upper Midwest.

Table 1. Daily temperature bias for the three sub-regions

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1	0.08	-1.14	-1.85	-1.60	0.22	-0.64	-0.79	-0.47	-0.17	-0.63
2	-2.47	-1.77	-1.39	-0.90	0.15	-0.28	0.68	0.25	-0.34	0.07
3	-2.36	-1.40	-0.82	-0.54	0.39	-0.02	0.82	0.26	-0.25	-0.01
4	-2.10	-1.28	-0.72	-0.83	0.22	-0.11	0.51	-0.13	0.15	-0.45
5	-2.09	-1.66	-1.82	-1.68	0.05	0.31	0.65	-0.16	0.32	0.28
6	-1.50	-2.02	-1.88	-1.65	-0.72	0.50	0.62	0.36	0.28	0.27
7	-1.98	-2.19	-1.98	-1.88	-0.40	0.22	0.77	0.92	-0.14	0.51
8	-2.65	-2.91	-3.00	-2.33	-0.50	0.25	0.17	0.88	-0.50	0.39
9	-3.33	-2.49	-3.36	-2.73	-0.35	0.00	-0.11	0.73	-0.59	0.31
10	-3.00	-1.78	-1.1	-1.52	0.36	-0.57	0.09	0.39	-0.35	0.41
11	-3.07	-2.16	-1.45	-0.98	-0.39	-0.41	0.70	-0.23	0.41	-0.16
12	-2.50	-1.79	-2.99	-1.63	-0.41	-0.04	1.15	-0.46	0.78	-0.19
13	-2.68	-2.63	-3.22	-1.29	0.07	0.23	0.93	-0.23	0.65	0.26
14	-1.67	-2.84	-1.69	-1.33	0.71	0.20	0.62	-0.06	0.09	0.58
15	-1.46	-1.94	-1.15	-1.64	0.54	0.20	0.50	-0.16	0.35	0.46
16	-1.54	-2.01	-1.79	-2.34	0.06	0.31	0.29	-0.08	0.52	0.58
17	-1.36	-2.33	-1.26	-1.95	0.91	0.42	-0.12	-0.10	0.48	0.55
18	-1.70	-2.34	-1.32	-1.89	1.47	0.01	-0.15	0.38	-0.03	0.12
19	-1.27	-1.83	-1.11	-1.09	1.77	-0.37	0.10	0.55	-0.73	-0.21
20	-2.04	-1.68	-0.95	-0.28	1.72	-0.5	-0.14	0.57	-0.22	0.28
21	-2.10	-1.36	-0.53	-0.59	1.48	-0.48	-0.78	0.03	0.36	0.23
22	-3.40	-2.16	-0.71	-0.23	0.89	-0.37	-0.48	-0.35	0.75	-0.03
23	-2.97	-2.73	-2.08	-1.13	0.15	-0.61	0.55	-0.03	1.12	-0.05
24	-2.87	-2.73	-2.04	-1.87	0.26	-0.54	0.76	-0.02	1.25	-0.25
25	-3.24	-2.23	-1.31	-0.73	0.20	-0.75	0.40	0.13	0.80	-0.76
26	-2.89	-0.74	-1.96	0.25	0.26	-0.61	-0.37	0.14	0.92	-0.98
27	-2.46	-0.77	-3.34	-0.29	0.10	-0.28	-0.40	0.12	0.66	-0.81
28	-1.49	-1.31	-3.36	-0.54	-0.35	0.12	-0.78	0.15	0.67	-0.43
29	-1.68		-3.89	-0.56	-0.46	-0.10	-0.41	0.29	0.21	-0.73
30	-1.17		-2.55	0.08	-1.00	-0.68	-0.41	0.25	-0.67	-0.47
31	-1.20		-1.67		-1.13		-0.36	0.05		-0.19

Table 2. Daily temperature gross-error for the three sub-regions

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1	1.76	1.90	2.62	2.64	1.85	1.93	1.60	1.46	1.27	1.47
2	3.11	2.56	1.98	2.04	1.79	1.86	2.32	1.53	1.34	1.42
3	2.88	2.16	1.82	1.90	2.46	1.61	2.04	1.47	1.25	1.38
4	2.43	2.29	2.08	2.36	2.50	1.59	1.97	1.36	1.37	1.18
5	2.39	2.54	2.82	3.08	2.57	1.64	1.81	1.33	1.41	1.37
6	1.88	2.58	2.75	2.99	1.93	1.58	1.78	1.33	1.27	1.45
7	2.44	2.62	2.70	2.70	1.77	1.59	1.64	1.46	1.36	1.59
8	2.91	3.27	3.64	2.68	1.50	1.46	1.48	1.46	1.47	1.67
9	3.39	2.79	3.89	3.34	1.65	1.53	1.51	1.41	1.49	1.76
10	3.13	2.25	1.96	2.72	2.04	1.71	1.37	1.36	1.46	1.56
11	3.17	2.68	2.23	2.46	1.75	1.68	1.43	1.50	1.39	1.44
12	2.68	2.22	3.31	2.65	1.58	1.55	1.61	1.52	1.47	1.23
13	2.87	3.17	3.59	2.77	1.86	1.41	1.55	1.50	1.41	1.22
14	2.12	3.25	2.43	2.61	2.07	1.30	1.43	1.39	1.33	1.53
15	1.95	2.39	2.14	3.00	1.95	1.41	1.36	1.20	1.35	1.53
16	2.04	2.53	2.81	3.60	1.78	1.48	1.33	1.31	1.40	1.53
17	2.12	2.97	2.23	3.16	1.90	1.61	1.39	1.22	1.40	1.55
18	2.52	2.81	2.49	2.97	2.11	1.48	1.53	1.38	1.29	1.51
19	1.95	2.18	1.98	2.49	2.25	1.47	1.47	1.36	1.35	1.42
20	2.60	2.12	1.96	2.06	2.25	1.64	1.40	1.38	1.24	1.61
21	2.54	1.89	1.65	1.50	2.27	1.57	1.61	1.25	1.17	1.44
22	3.71	2.84	1.90	1.97	1.88	1.38	1.53	1.35	1.34	1.70
23	3.32	3.34	2.89	3.28	1.83	1.55	1.49	1.29	1.52	1.75
24	3.28	3.27	2.82	3.22	2.09	1.58	1.43	1.18	1.61	1.73
25	3.51	2.77	2.20	2.24	1.74	1.72	1.37	1.24	1.33	1.61
26	3.30	1.39	2.61	2.86	1.89	1.63	1.34	1.30	1.35	1.60
27	3.03	1.66	3.79	1.48	1.79	1.47	1.52	1.25	1.32	1.64
28	2.33	2.10	3.82	1.53	1.90	1.36	1.58	1.26	1.32	1.48
29	2.40		4.10	2.49	1.84	1.46	1.38	1.22	1.32	1.48
30	1.77		3.13	2.64	1.94	1.55	1.38	1.23	1.53	1.44
31	1.69		2.74		2.08		1.44	1.24		1.56

Regional Emissions Modeling

Several test runs of the EMS emissions modeling system have been performed on the beta versions of the mercury inventory for point, area, nonroad and mobile sources. In addition to the quality assurance reports that EMS generates automatically, report processors have been written and applied to assist in the identification of outliers (possible erroneous sources of emissions.)

The speciation profiles and processors continue to be updated to accommodate the substance of the inventories available for mercury. Atmospheric Chemistry Model ready files for elevated point, low-level area, and mobile were provided to ENVIRON to test the new CAMXHG model.

Inventory Development

Several tasks related to the 1999 domestic, Canadian and Mexican mercury emissions inventories were completed.

- Replaced 1999 HAP National Emissions Inventory (NEI) draft version 3 as the base 1999 mercury emissions inventory with 1999 National Air Toxics Assessment (NATA) emissions inventory (EI) to take advantage of some quality assurance and data augmentation performed by EPA involving emission release point physical parameters (e.g. stack heights, stack temperatures, stack coordinates etc.), temporal profiles, and comparisons of annual and episodic emissions. The 1999 NATA EI is based on the 1999 HAP NEI draft version 3.

- Performed some additional quality assurance and data augmentation on the 1999 NATA EI by adding source classification codes (SCCs) where they were missing or invalid and removing some extreme outliers.

- Formatted the 1999 NATA EI into National Emissions Inventory Input Format 2.0 (NIF2.0) for processing by EMS-2001.

- Created an initial Canadian EI for sources south of 60°N by consolidating 1995 national data provided by Environment Canada and 1999 Ontario data provided by the Ontario Ministry of the Environment through the Great Lakes Regional Air Toxic Emissions Inventory Project. At this point, the Canadian EI is preliminary especially for the 1995 data. Outside of Ontario, there isn't any onroad data or 1999 data for any category. Non-Ontario nonroad data is limited to commercial marine. SCCs are missing for many processes. In general spatial resolution is poor, emissions are assigned to the county centroid or grid cell centroid depending on the data source. The release of a Canadian 2000 EI is anticipated later this year.

- Contacted Gildardo Acosta of Acosta and Associates about acquiring a Mexican EI. A preliminary Mexican mercury EI was prepared by Acosta and Associates for the Center for Environmental Cooperation (CEC).

- Began review of less extreme outliers in 1999 NATA EI using the 1999 HAP NEI version 3 which contains more descriptive and detailed information than the 1999 NATA EI.

- Continued the refinement and revision of the Quality Assurance / Quality Control (QA/QC) Plan.

In the 2003, we are still planning to take measurements at potential significant mercury sources including vehicle recyclers, crematoriums and lime kilns.

Data Analyses

There are no updates for this topic at this time.

Mercury Monitoring

The Wisconsin DNR's Air Program continued an active program for mercury monitoring in the first calendar quarter of 2003. Deposition monitoring for mercury continued at six sites including a new urban site. Ambient mercury monitoring was conducted at two ground stations. Aircraft sampling for mercury was completed. A summary of the monitoring projects follows.

Deposition Monitoring

Wisconsin has six existing monitoring stations as part of the National Mercury Deposition Network (MDN) operated by the National Atmospheric Deposition Program (NADP). The sites are located at Brule River, Trout Lake, Lake Du Bay, Devils Lake, Lake Geneva, and Milwaukee. Five of these sites collect weekly wet deposition samples. A sixth site, at Devils Lake, is operated as an event site where the sample is removed from the collector after each rainfall event. Wisconsin newest site began operation in October 2002. This site new site located on the University of Milwaukee's North Campus is the first urban deposition site in Wisconsin. Information about the mercury deposition program as well as historical data for the Wisconsin monitoring stations can be found at the National Atmospheric Deposition Programs web site (http://nadp.sws.uiuc.edu/).

Ambient Monitoring

The Mercury Analysis Trailer (MAT) shared with Michigan and Minnesota was available to the WDNR from mid-February until the end of March. The MAT contains two TEKRAN 2537a analyzers and supporting equipment. During this time period monitoring staff conducted two short-term monitoring projects. These projects were to investigate mercury concentrations down wind of large power plants. The MAT was moved to the Chiwaukee Prairie monitoring site (55-059-0019). The Chiwaukee Prairie site in far southeast Wisconsin is located near the Pleasant Prairie Power station. The MAT's second TEKRAN analyzer was moved to a monitoring trailer at the DNR's Devils Lake site (55-111-0007). The Devils Lake site is located directly west of the Columbia Power Station. The data collected on these projects is in review and the results should be reported in the next quarter.

A report on air monitoring near the Vulcan Chemical Company in Port Edwards was released and is available on the DNR's web site at
http://www.dnr.state.wi.us/org/aw/air/MONITOR/vulcanhgmon.pdf.
The report covers two short-term air monitoring project at the facility from April 8 to May 16, 2002 and from August 16 to September 27, 2002.

Aircraft Monitoring

The Wisconsin DNR's winter aircraft monitoring project was completed with the last flight made on February 17, 2003. Aircraft monitoring included sampling for mercury using gold traps for long duration samples. The gold traps are commercially prepared glass tubes filled with gold-coated sand. The tubes will trap mercury from air drawn through the tubes. The tubes were analyzed using the protocol in USEPA Method IO-5. Samples were collected on periodic (approximately 1-in 12 days) aircraft flights. The project began in August 2002 and with a route expected to measure mercury in the air above Lake Superior.

Miscellaneous

David Grande attended "*Measuring Atmospheric Mercury: Goals, Methods, and Results"* a workshop held March 26-27 in Lansing, MI. The Michigan Department of Environmental Quality and the U.S. Environmental Protection Agency sponsored the workshop. At the Workshop, David was a featured speaker and reported on the Wisconsin DNR's monitoring efforts. David also assisted the MDEQ in a demonstration of the MAT.

Monitoring section staff completed and submitted grant applications for two proposed monitoring projects. The first grant was submitted to the FOCUS ON ENERGY ENVIRONMENTAL RESEARCH PROGRAM requested funding for a study of gaseous mercury fluxes. A second grant was submitted to the US EPA's Great Lake Program Office and requested funding to upgrade equipment on the MAT to provide monitoring for Reactive Gaseous Mercury (RGM) and particulate bound mercury.

Computer Resources

There are no updates for this topic at this time.